

OPINION | THE WEEKEND INTERVIEW

# Physics, Biology and Economic Inequality

Adrian Bejan's revolutionary theory proposes that the same laws of nature produce rivers, trees, human beings and wealth distributions.

By J. Peder Zane

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ILLUSTRATION: KEN FALLIN

*Durham, N.C.*

As we move toward our seats for lunch at Duke University, Adrian Bejan says he's studied the Journal's Weekend Interviews and that they usually begin with the

subject declaring “what everybody else believes is wrong.”

“So I made a list for you,” says Mr. Bejan, 70, a professor of mechanical engineering. He disputes a set of ideas that have shaped Western thought at least since Darwin: that nature is unpredictable, that evolution is random, and that the world is on a steady march toward disorder.

“This couldn't be more incorrect,” he says. “It is at odds with the purpose of science, which is useful precisely because it allows us to predict what's going to happen, but with the evidence we see all around us that nature and human society are steadily and measurably evolving in ways that are better for everyone and everything that moves—not because of chance.”

Now, there's an icebreaker, and from a man who's been breaking ice in science for some time. Born in Romania, Mr. Bejan came to the U.S. at 19 to study at the Massachusetts Institute of Technology. He specialized in thermodynamics—the study of heat, power and other forms of energy—but a “Eureka!” moment in 1995 broadened his horizons. It happened in France as he listened to a lecture by Ilya Prigogine, winner of the 1977 Nobel Prize in Chemistry. Prigogine asserted that the treelike shapes that abound in

nature—in lightning bolts and river basins, in our circulatory systems and the neural networks of our brains—arise by “throwing the dice,” without rhyme or reason.

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OPINION LIVE EVENT

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“I knew he was wrong,” says Mr. Bejan, who had already created his own trees, “not by accident but from an idea,” while working to cool computer systems. Flow systems arise to move a current from here to there; Mr. Bejan imagined correctly that tree-shaped pieces of highly conductive material would convey heat away from the circuits more easily.

In a flash, he knew that his insight applied to—well, everything. On the flight back to the U.S., he formulated what he called the “constructal law”: “For a finite-size flow system to persist in time (to live), it must evolve with freedom in such a way that it provides easier access to the imposed currents that flow through it.”

In layman’s terms, that means all shape and structure—all “design” in nature—evolves in a predictable direction: toward facilitating the movement of whatever flows through it. Designs evolve by configuring and reconfiguring themselves to move more stuff more easily. The world around us reveals a story of movement, flow, life, order and change. “You can’t take a picture of reality,” Bejan says, “because it’s a movie, or a cartoon, depending on your sensibility.”

Sometimes this evolution happens over millions of years. Raindrops don’t merely puddle and seep across the ground—an inefficient way to move. Instead they self-organize into the familiar treelike river basins that cover the globe—the networks of brooks, streams, large tributaries and main channels, such as the Mississippi or the Danube—that move more water more quickly from the plain to the river’s mouth. The circulatory systems of humans and other animals have a similar configuration, with a single main channel, the aorta, that pumps blood throughout the body through networks of arteries, veins and capillaries.

This evolutionary phenomenon can also happen in an instant, as when treelike lightning bolts flash across the sky, an efficient design for moving electricity from a cloud to the ground or to another cloud.

If Darwin knocked humans off our pedestal by suggesting we’re not so different from monkeys, the constructal law teaches that we are not so different from trees or rivers. “Life is not a strictly biological phenomenon. Life is movement, and all movement is physics,” Mr. Bejan says. “It’s about moving stuff from here to there. The constructal law observes the natural tendency of everything to evolve freely to keep moving. When that

movement stops, whether it's a human being or a dried river bed, it is 'dead,' according to thermodynamics."

The religiously inclined might see the unity of this theory as pointing toward an idea about God. That's not Mr. Bejan's view. "There is design change—evolution—but no designer," he says. "People ask me, 'Why does this design happen?' The answer is it just does, which is why it is a law,

a property of nature."

Yet the constructal law also applies to the products of human design. "What nature tends to do on its own, we tend to do in our life movement, because we too are part of the flowing nature," Mr. Bejan says. Think of roads. Highways move large numbers of vehicles quickly, but the design also includes avenues, streets and lanes, and the paths we walk to get to our vehicles.

"We can all witness evolution in new speed records at the Olympics, and in the shapes and speeds of new airplane models," he continues. "There is evolution galore in our textbooks on the history of civilization, which chronicle humanity's successful efforts to construct designs—laws and transport systems, infrastructure, architecture, art, language, economic and political systems, communication networks—to move more people, goods and ideas more easily and with greater lasting power."

Mr. Bejan says engineers are beginning to apply his insights. "For example, now we know that the engines on future commercial airplanes should be one-tenth of the size of the whole body, and that the wingspan should be the same as the fuselage length. For future helicopter designs, we know in advance that the rotor diameter should match the length of the body. We know that future ice-making machines should discharge ice with a particular rhythm, just like a lung that exhales with a particular rhythm."

Mr. Bejan's big-picture work stands in contrast with the trend in science toward asking ever-smaller questions—in physics, seeking answers on a subatomic scale. "I invented the field of life and evolution as physics—to look at life and evolution as natural phenomena everywhere and in all realms," he says. "This new physics is not strictly about tree-shaped flows. It is about all the morphing architectures that are macroscopic, free, observable and measurable—for example, the round cross-sections we find in blood vessels, subterranean rivers and the tunnels dug by worms; or the seemingly precise rhythms of breathing, running, wings flapping, flags waving and smoke plumes dancing. The science of form comes predictively from principle, not from analogy. Evolution is physics, not opinion."

Although his ideas are new, he says people have long had “good hunches” about them. Idioms such as “go with the flow” and “path of least resistance” reflect colloquial efforts to describe this phenomenon. Popular writers, including Steven Pinker (“Enlightenment Now”), Matt Ridley (“The Evolution of Everything”) and even Jordan B. Peterson (“12 Rules for Life”) have also touched on the same idea. But that work “is descriptive,” Mr. Bejan says. “It provides the observation that certain patterns and trends emerge. The constructal law is theoretical. It is a purely mental viewing of what should happen, and these predictions are later tested empirically.”

Mr. Bejan says all this with a smile, in part because he loves the battle, but also because after years in the wilderness, he is seeing scholars in a variety of fields embrace his revolutionary views. Conferences on his work are held regularly throughout the world—the 12th is slated for Brazil in March. Last year he was awarded one of the most prestigious prizes in science, the Benjamin Franklin Medal, for the constructal law and a body of work that includes more than 650 peer-reviewed papers and 30 books, including “The Physics of Life” (2016) and the one we wrote together, “Design in Nature” (2012).

The constructal law also has implications for social sciences, including economics. Whereas Darwinism and Marxism stress competition and zero-sum outcomes, the constructal law observes that individual entities, including human beings, have a natural tendency to join groups because it helps each of them “flow” more easily.

“Everywhere,” Mr. Bejan says, “we see this phenomenon: a few large movers and many smaller ones, all working together for the good of the whole. The large channels are not robbing the smaller ones; both are serving each other.” That leads to what may be Mr. Bejan’s most provocative claim: that economic and social inequality is the inevitable result of physical laws. “Hierarchy is not imposed, it is natural,” he says. “Equality, however, is artificial, because it violates the law of evolution in nature.”

Mr. Bejan emphasizes that he does not mean this as a political statement or a moral defense of inequality: “Physics is not about justice or fairness, but about what happens in nature.” The “physics origin” of inequality, he says, “is that nothing moves unless it is pushed. Pushing comes from power, and power comes from fuel for machines and food for animals. Fuel use is the physics measure of movement, and, like movement, fuel use is distributed nonuniformly around the globe.

“Next, because the amount of fuel consumed annually by a population is directly proportional to its annual wealth, the GDP, the life movement of a population—the economy—becomes hierarchical naturally, with a few large and many small movers. So physics and economics are two sides of the same coin. The same hierarchical-flow architecture accounts for both.”

Harnessing that power rather than fighting it, Mr. Bejan argues, is a better way of helping the disadvantaged. “If we think about inequality as a physical phenomenon, perhaps that can inform the discussion, so that instead of trying to erase these differences, we can see how to connect the

slow-moving pockets of society to the big-flow architecture,” he says. “Artificial constraints that limit the freedom of a system to change might work for a while. But they are ultimately doomed because they are not just fighting against the will of the people but the laws of physics.”

Systems must evolve and build on the designs already in place. Thus it is folly to think one can impose radically new political and economic systems on different nations. It’s not just the lack of a specific political tradition and the absence of the channels needed to move people, ideas and goods, Mr. Bejan says: “The chief impediment is the absence of a culture that encourages and rewards freedom to question authority, to speak up, inquire, innovate and implement change.”

*Mr. Zane is an editor at Real Clear Investigations.*

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